

A New Species of Cone Shell (Gastropoda: Conidae) from the Saharan Coast of Northwestern Africa

Edward J. Petuch¹ and David P. Berschauer²

¹Department of Geosciences, Florida Atlantic University, Boca Raton, Florida 33431

epetuch@fau.edu

²25461 Barents Street, Laguna Hills, California 92653

shellcollection@hotmail.com

ABSTRACT A new species of *Lautoconus* (Conidae: Puncticulinae) is described from the intertidal rocky environments of Dahkla Bay, central Western Sahara. The new species is most similar to *L. guanche* from the Canary Islands, but differs in having a stockier, more darkly-colored, and lower-spired shell. The new species, here named *L. saharicus* n. sp., is endemic to Dahkla Bay and the Dahkla area of Western Sahara, roughly 400 km south of the Canary Islands.

KEY WORDS Cone shell, Conidae, *Lautoconus*, Western Sahara, Northwestern Africa.

INTRODUCTION In June 1974, the senior author visited the coast of northwestern Africa as part of his Masters Degree research on the molluscan biogeography of West Africa. At that time, the coastal region of northwestern Africa, between Morocco and Mauritania, was referred to as "Spanish Sahara" and was essentially uninhabited, containing only a few Spanish Foreign Legion Posts, scattered small coastal fishing villages, and nomads such as the Tuaregs and Sahrawis. In 1975, Spain relinquished its control over Spanish Sahara, after three years of civil war, and the newly-independent country then became known as "Western Sahara". The conflicts have continued on into the present, as Western Sahara subsequently has been claimed, and occupied, by both Morocco and Mauritania. Although often shown on maps as the "Western Sahara District" of Morocco, we will refer to the country as "Western Sahara" in this paper. The local inhabitants now refer to their country as the "Sahrawi Arab Democratic Republic" and are resisting Moroccan rule, making it a dangerous place to visit and collect shells.

The only regularly-accessible city in Western Sahara, both in 1974 and now, is the small coastal town of Dahkla, roughly halfway between Cap Boujdour (Cabo Bojador), Morocco and the tip of Cap Blanc (Cabo Blanco), on the Mauritania-Morocco border (Figure 1). Formerly known as "Villa Cisneros", Dahkla was a Spanish Foreign Legion post when the senior author visited the city in 1974 and it was accessible by airplane, with two flights a week, from Tenerife Island, Canary Islands. The town sits on a narrow peninsula (formerly known as the "Peninsula de Rio de Oro") that separates the North Atlantic Ocean from the large and elongated Dahkla Bay (previously referred to as the "Rio de Oro") and is located in one of the most desolate areas of the Sahara Desert. With almost no rainfall, the area surrounding Dahkla Bay is devoid of any vegetation and closely resembles photographs of the surface of Mars. Being elongate and fjord-like, as in the Bay of Fundy in Nova Scotia, Dahkla Bay has very large tidal fluctuations and vast sand flat areas are exposed during low tide. The shoreline of Dahkla Bay, along the eastern side of the Dahkla Peninsula, is lined with low cliffs that are composed of a

thick sandstone surface layer sitting on top of loose desert sand. Wave action has undermined much of this coastline and large blocks of the sandstone have broken off the top of the cliffs and have fallen to the cliff base, producing a large talus area that extends all around the bay.

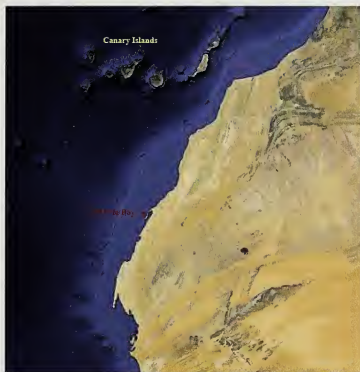


Figure 1. Map of Western Sahara region

The vast sand flats and rocky shorelines of Dahkla Bay offer a variety of habitats for intertidal mollusks. Being at the extreme northern edge of the Guinean Molluscan Province (Western Sahara south to southern Angola) and in a relatively cold water area, the molluscan fauna in Dahkla Bay is very impoverished, with only a few species of gastropods being present. The sand flats support a very small fauna of gastropods, but these are present in very large numbers of individuals. Only four species were commonly collected, and these included the cone shell *Kalloconus byssinus* (endemic to Western Sahara and Mauritania), the volutes *Cymbium cymbium* and *C. tritonis*, and the cysticid *Persicula cingulata*. Likewise, the rocky shoreline was equally impoverished, with only three species of

gastropods being collected, but again in large numbers of individuals. These included the muricids *Ocenebrina miscowichae* and *Hexaplex canariensis* and a small cone shell in the genus *Lautoconus*. Initially, this distinctive cone was referred to as "*Conus guinaicus*", and was considered to be only a dwarf variant of the much larger and more colorful *L. guinaicus* from the tropical waters of Senegal. Specimens were donated to the Smithsonian Institution and this interesting cone shell was relegated to a foot note in the senior author's field notebook.

Cone shells similar to the Western Sahara *Lautoconus* were also known to inhabit the eastern Canary Islands, and for years these were also incorrectly relegated to the taxon "*Conus guinaicus*". Lauer (1993) demonstrated that the Canary Islands cone was not "*C. guinaicus*" but was, actually, a new and separate species which he named "*Conus*" *guanche* (for the Guanches, the original inhabitants of the Canary Islands; Lauer, 1993). In the same paper, he also described a color form or variety *nitens*, which has been found on some of the eastern islands of the archipelago. Because of superficial similarities in shell shape, size, and color, most cone workers have used the taxon *guanche* for the Western Saharan species. This taxonomic assignment is untenable, especially when considering that *L. guanche* has a paucispiral protoconch and non-planktonic larvae with limited dispersal abilities, and that the Dahkla Bay area is over 400 km south of the southernmost islands of the Canary Archipelago, contains a completely different type of molluscan fauna (tropical-subtropical), and belongs to a different biogeographical faunal region (the Guinean Molluscan Province). Upon closer examination of recently-collected specimens from Dahkla, purchased from Rika Goethaels and Fernand De Donder of Belgium, we found that the Western Saharan cone shell exhibits consistent differences when compared

to the Canarian *L. guanche* and represents a previously-overlooked unnamed species. This new cone is described in the following sections.

SYSTEMATICS

Class Gastropoda

Subclass Orthogastropoda

Superorder Caenogastropoda

Order Sorbeoconcha

Infraorder Neogastropoda

Superfamily Conoidea

Family Conidae

Subfamily Puncticulinae

Genus *Lautoconus* Monterosato, 1923

Lautoconus saharicus Petuch and Berschauer, new species

(Figures 2 A, B, and C)

Description: Shell of average size for genus, stocky, inflated, bulbous, only slightly glossy, with matte finish; shoulder broad, rounded, only slightly angled; spire low, broadly pyramidal; body whorl smooth and silky, with 20-24 very fine, low, closely-packed spiral threads around anterior end; body whorl base color dark sky blue or deep bluish-green, overlaid with numerous large, dark brown amorphous flammules, generally evenly-spaced and arranged in zebra-like pattern; brown flammules often composed of 3 sections, being broader and wider along edge of the shoulder, around midbody, and around anterior end, creating effect of 3 broken spiral bands of flammules; spire whorls base color dark sky blue, heavily marked with thick, evenly-spaced dark brown crescent-shaped flammules, producing distinctive checkered appearance; aperture proportionally-wide and flaring, colored deep purple-brown on the interior; inner edge of lip colored pale yellow-white; purple-brown interior marked with single narrow white band

just anterior of mid-body line; periostracum thin, pale yellow, transparent.

Type Material: HOLOTYPE- length 27.4 mm, LACM 3333; PARATYPE- length 22.6 mm, LACM 3334; Other material examined includes 5 specimens in the David Berschauer collection, 30.2 mm, 25.6 mm, 21.7 mm, 19.8 mm (Figure 2C), and 16.5 mm, and two specimens, lengths 28.1 mm and 25.8 mm in the research collection of E.J. Petuch, all from the same locality and depth as holotype. Two more specimens, collected by senior author in 1974, are currently un-cataloged and in general cone collection of United States National Museum of Natural History, Smithsonian Institution, Washington, D.C.

Type Locality: Dahkla (formerly Villa Cisneros), western side of Dahkla Bay, Western Sahara (formerly Spanish Sahara), western coast of Sahara Desert, northwestern Africa. Types collected under large slabs of sandstone, at base of low cliffs along eastern side of Dahkla Peninsula (western side of Dahkla Bay), at low tide.

Range: Endemic to Dahkla Peninsula (Peninsula de Rio de Oro) and Dahkla Bay, Western Sahara.

Ecology: *Lautoconus saharicus* is restricted to quiet, sheltered intertidal areas in Dahkla Bay, where it occurs cryptically under large slabs of sandstone along the shoreline. Co-occurs with two muricid gastropods, *Hexaplex canariensis* and *Ocinebrina miscowichae*, and numerous small oysters and barnacles.

Etymology: Named for the Sahara Desert, which is adjacent to, and surrounds, the type locality.

Discussion: Of the known Mediterranean and West African *Lautoconus* species, *L. saharicus* is most similar to the Canary Islands endemic *L. guanche* (Lauer, 1993) (Figure 2 D) but consistently differs in the following ways:

1. *L. saharicus* has an inflated, compact, and stocky body whorl, while *L. guanche* has a proportionally longer, more protracted, and fusiform body whorl;
2. *L. saharicus* is proportionally much broader across the shoulder than *L. guanche*;
3. *L. saharicus* has a more rounded and distinctly less-angled shoulder than *L. guanche*;
4. *L. saharicus* has a much lower, almost flattened spire, while *L. guanche* has a much higher, more elevated, and protracted spire with distinctly more sloping and angled spire whorls;
5. *L. saharicus* is a more brightly-colored shell, with a base color of dark blue or bluish-green, overlaid with irregular dark brown longitudinal flammules, often arranged in a zebra pattern, and covered with amorphous dark brown speckling; *L. guanche* is a more lightly-colored shell, having a pale blue or blue-gray base color that is overlaid with widely-scattered light khaki or tan amorphous flammules;
6. the interior of the aperture of *L. saharicus* is consistently a dark purplish-brown color, while the interior of the aperture of *L. guanche* is always a light tan-brown color;
7. the spiral threads around the anterior end of *L. saharicus* are much finer and more numerous than the coarser spiral threads and small cords around the anterior end of *L. guanche*;
8. the spire whorls of *L. saharicus* are marked with proportionally-large, evenly-spaced wide dark brown flammules, producing a distinctive checkered appearance; the spire whorls of *L. guanche* are marked with only thin, irregularly-spaced pale tan flammules, often with large colorless gaps.

Lautoconus saharicus is the only cone shell that lives in the calm water, sheltered rocky

intertidal areas of Dahkla Bay, where it often occurs in large numbers under slabs of sandstone. This Western Sahara endemic is part of an impoverished, but highly endemic, molluscan fauna that is restricted to the Sahara Desert coastline in a stretch ranging from Cabo Bojador to Cabo Blanco. Other important Western Saharan endemics include the muricids *Ocenebrina purpuroidea* and *Jaton hemitripterus*, both of which occur in the rocky intertidal areas on exposed coastlines with stronger wave action. These characteristic Saharan species, along with the endemic muricid *O. miscowichae* and the endemic cone shell *Kalloconus byssinus*, are not found on the Canary Islands, demonstrating that there is a substantial ecological and biogeographical barrier between the Dahkla area and the Canary Islands. *Lautoconus guanche*, itself, has limited dispersive ability, as it is present only on the eastern Canary Islands of Fuerteventura, Lanzarote, Gran Canaria, and Tenerife, but is absent from the western Canary Islands of La Palma, El Hierro, and Gomera (Munoz Sanchez, 2014). If this Canary Islands endemic is unable to disperse throughout one-half of its resident archipelago, then it would be even more difficult to extend its range southward over 400 km to the Dahkla Bay area. The morphological similarities of *L. guanche* and *L. saharicus*, then, appear to be exclusive sister taxa which may have evolved from a common more widespread ancestor.

A recent paper by Cunha, *et al.*, 2014 studied the *L. guanche* and *L. guanche nitens* populations in the Canary Islands, and Tarfaya on the adjacent mainland, primarily utilizing DNA sequence data from two mitochondrial alleles (NADH4 and 16s RNA) and one nuclear allele (ITS1). Radular tooth morphology and a geometric morphometric analysis were also undertaken, and the analysis of these data led to the authors' conclusion in that paper that, in

spite of the observed phenotypic differences, all the individual specimens studied belonged to one single species (Cunha, *et al.*, 2014). Molecular studies such as this are the result of the modern trend of “DNA bar-coding”, which embodies what has been referred to by cone expert John Tucker as “molecular hubris” (personal communication). Such studies fail to meet the requirement of total evidence for several reasons: they focus primarily on mitochondrial DNA (rather than the organism’s autosomal DNA); they fail to select sufficient nuclear alleles from the thousands of genes in the subject organism for meaningful study; and, most importantly, they are based upon the unstated assumption that natural selection operates at the level of individual nucleotides rather than at higher organizational levels. (Fitzhugh, 2006; Fitzhugh, 2016; Thompson, *et al.*, 2014). The purpose of both multivariate statistical analysis and Bayesian analysis is to indicate correlations which are presumed to explain the variability observed in natural populations of organisms; when these analyses do not indicate correlations that are presumed to explain that variability, it can only be interpreted that the correct data was not included in the study.

The senior author extensively explored and surveyed the molluscan fauna of western Africa and Spanish Sahara and no *Lautoconus* individuals similar to *L. saharicus* were found between Tarfaya and Dahkla Bay. It should be noted that *L. saharicus* is found in a completely different habitat than that of the Mediterranean and Canary Islands *Lautoconus* species, and that it co-exists with a completely different molluscan fauna that belongs to a different biogeographical province. In the case of *L. saharicus*, all the morphology, biogeography, ecology, geological history, and oceanography points to *L. saharicus* being a separate species. It is likely that *L. guanche nitens* is also a

distinctive subspecies that is restricted to the eastern Canary Islands, particularly Lanzarote and Fuerteventura. Therefore, even within the Canary Archipelago, true *L. guanche* does not range very far, demonstrating that these cones have non-planktonic larvae and probably are direct developers with limited dispersal abilities.

The genus *Lautoconus* is now known to contain 22 valid species and ranges from the eastern Mediterranean Sea to the Canary Islands, and southward along the African coast to Gambia. Of these known species, 15 are endemic to the Cape Verde Peninsula region of Senegal and represent one of the largest conid species radiations known from West Africa. We recognize the following species as valid taxa:

MEDITERRANEAN SEA (Mediterranean Molluscan Province)

Lautoconus desidiosus (A. Adams, 1854)
Lautoconus vayssieri (Pallary, 1906)
Lautoconus ventricosus (Gmelin, 1791)

CANARY ISLANDS (Canarian Subprovince of the Mediterranean Province)

Lautoconus guanche (Lauer, 1993)
Lautoconus guanche nitens (Lauer, 1993)

WESTERN SAHARA (West Saharan Subprovince, Guinean Province)

Lautoconus saharicus Petuch and Berschauer, new species

SENEGAL (Senegalian Subprovince, Guinean Province)

Lautoconus belairensis (Pin and Tack, 1989)
Lautoconus bruguieresii (Kiener, 1845)
Lautoconus cacao (Ferrario, 1983)
Lautoconus cloveri (Walls, 1978)
Lautoconus dorotheae (Monnier and Limpalaer, 2010)
Lautoconus echinophilus (Petuch, 1975)

Lautoconus franciscanus (Hwass, 1792)
(= *unifasciatus*)
Lautoconus guinaicus (Hwass, 1792)
Lautoconus hybridus (Kiener, 1845)
Lautoconus lamarcki (Kiener, 1845)
Lautoconus mercator (Linnaeus, 1758)
Lautoconus pineaui (Pin and Tack, 1995)
Lautoconus tacomae (Boyer and Pelorce, 2009)
Lautoconus taslei (Kiener, 1845)
Lautoconus trencarti (Nolf and Verstraeten, 2008)

GAMBIA (Senegalian Subprovince, Guinean Province)

Lautoconus orri (Ninomiya and daMotta, 1982)

Future research, particularly in the Mediterranean Sea, will doubtlessly demonstrate that several more valid and previously-overlooked *Lautoconus* species exist.

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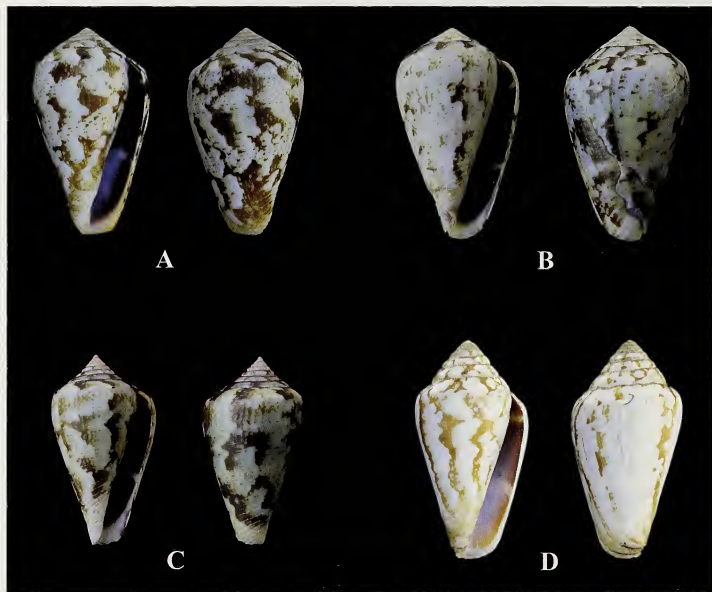


Figure 2. A = *Lautoconus saharicus* n. sp., Holotype, length 27.4 mm, LACM 3333, Dakhla Bay, Western Sahara; B = *L. saharicus* n. sp., Paratype, length 22.6 mm, LACM 3334; C = *L. saharicus* n. sp., length 19.8 mm, Berschauer Collection; D = *L. guanche*, length 29.1 mm, Santa Cruz de Tenerife, Tenerife Is., Canary Islands, Berschauer Collection.